

Class 1000

User Manual



Note

The following defined terms are used throughout this manual to bring attention to the presence of hazards of various risk levels, or to important information concerning the life of the product.

△ Warning

Indicates presence of a hazard which can cause severe personal injury, death or substantial property damage if ignored.

△ Caution

Indicates presence of a hazard which will or can cause personal injury or property damage if ignored.

△ Note

Indicates special instructions on installation, operation or maintenance which are important but not related to personal injury hazards.

These instructions assist in obtaining efficient, long life from Marley cooling equipment. Direct additional questions concerning cooling tower operation and maintenance to your Marley sales office or representative. Always include your tower serial number when writing for information or ordering parts. Look for this number on the nameplate located on the tower access door.

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General

A cooling tower, like any heat exchanger, exchanges all heat imposed upon it from one fluid to another fluid. For a cooling tower, heat from the water is exchanged into the air. The plant process replenishes the heat to the water, typically at another heat exchanger such as a condenser. A cooling tower differs from many heat exchangers in that heat is transferred in two forms—sensible and latent heat. As heat is transferred from the water, the air temperature increases (sensible) and the air's water content, or humidity, also increases (latent). As the heat load, inlet air wet-bulb temperature, or airflow on a cooling tower changes, the cooling tower will respond by finding a new equilibrium with the process. The cooling tower will still dissipate all the heat from the process, but at new water temperatures.

The cooling tower cold water temperature is the supply water temperature to the condenser, and changes in the cold water temperature usually affect efficiency of the plant output. Although the reduced cold water temperatures that result from maximum fan power utilization are usually beneficial to plant output, the amount of fan power affects the cost of running the cooling tower. As these variables interact on a cooling tower, the operator must find the proper trade-off between these opposing forces.

These instructions will assist in obtaining efficient, long life from Marley cooling equipment. Direct additional questions concerning tower operation and maintenance to your Marley sales office or representative. Always include your tower serial number when writing for information or ordering parts. Look for this number on the nameplate located on the tower access door.

Before Start-up

△ Caution

SAFETY—*Temporary safety barricades should be placed around any exposed openings in the operating (or nonoperating) tower, safety harnesses should be worn by personnel where appropriate, and other safety precautions should be taken in compliance with OSHA regulations and standards.*

CLEANING—Remove any dirt and trash which has accumulated in the hot water distribution basins. Clean any nozzles that are clogged. Remove any sediment from the cold water basin, sump and screens. Use a water hose to flush cold water basins.

△ Note

If you are restarting or recommissioning a previously used tower, see Warning on page 17.

INSPECTION—It is imperative that all operating assemblies be inspected before they are placed in operation. The following is a list of components to be checked before starting the tower:

- 1 Check the drive shaft alignment and realign if necessary. Refer to the **Marley Drive Shaft Service Manual** for more information.
- 2 Check the tightness of bolts that attach mechanical equipment supports to the tower framing. Check the tightness of bolts in fan cylinder joints and fan cylinder anchorage.
- 3 Check concrete structural surfaces for spalling and cracks. Consult a Marley structural engineer for evaluation and repair procedures.
- 4 Check tightness of the following bolted joints in the fan and drive assemblies:
 - Fan hub clamp bolts. See Marley **Fan User Manual** for correct torque setting.
 - Fan hub cover bolts. Where applicable.
 - Geareducer® and motor mounting bolts.
 - Drive shaft coupling and guard bolts.
 - Refer to Marley Drawing 91-398 for mechanical equipment hold-down fastener installation.
- 5 Check the Geareducer oil for sludge or water by draining off and testing a sample as outlined in the Marley **Geareducer Service Manual**. Check the Geareducer oil level at the “oil level” mark on the side of the case. Add oil as required. The oil level placard must be adjusted so that its “full” mark is at the same elevation as the “full” mark on the side of the Geareducer case. Check oil lines to be sure there are no leaks and all joints



are tight. See the **Geareducer Service Manual** for oil filling procedure and recommended lubricants.

6 Rotate the fan by hand to be sure it is free to rotate and that it has correct tip clearance as indicated in the Marley **Fan Owner's Manual**.

7 Check the motor insulation with a "Megger". See the Maintenance Section of the Marley **Electric Motor Service Manual**.

8 Lubricate the motor according to motor manufacturer's instructions.

9 Test run each fan separately for a short time. Check for excessive vibration or unusual noise. If either is present, see **Troubleshooting** on page 22 of this manual. The fan must rotate clockwise when viewed from above. Recheck the Geareducer oil level.

10 Check functioning of makeup water supply and correct basin levels.

11 Make sure the blowdown or bleed-off will carry the proper amount of water. See **BLOWDOWN** on page 18

OPERATE WATER SYSTEM—Complete steps 1 thru 4 under **Initial Starting Procedure** on page 7. Circulate water over the tower continuously for several days before starting the mechanical equipment and putting the tower into continuous operation.

△ **Caution**

Do not circulate water over the tower in freezing weather without a heat load. See **Caution** on page 7.

Initial Starting Procedure

- 1 Fill the cold water basin and circulating water system to a level 13 mm (1/2") below the overflow.
- 2 Completely open all hot water flow control valves. (If the tower is equipped with a bypass, the bypass valve should be closed unless start-up is in cold weather. See **Routine Starting Procedure** on page 7.
- 3 Prime and start the circulating water pumps one at a time. Increase the flow of circulating water gradually to design water rate to avoid surges or water hammer which could damage the distribution piping.
- 4 When flow has stabilized at or near the design rate, adjust water makeup to maintain the level that the water has pumped down to in the cold water basin. See **COLD WATER COLLECTING BASIN** on page 9. This should coincide reasonably with the recommended operating water level indicated on the Marley project drawings.
- 5 Adjust flow control valves to equalize the hot water depth in the distribution basins. Adjust deepest water level basins first. Lock valves in desired position with the valve locking bar.
- 6 Start the fan(s). Allow 30 minutes operating time to permit Geareducer oil to come up to operating temperature, then check motor load with watt meter, or take operating volt and ampere readings and calculate motor HP. Refer to Marley **Fan User Manual** for instructions.

△ Caution

If it is necessary to pitch fans to pull correct contract horsepower, measure results when circulating design water rate at design hot water temperature. HP will change with air density. LOCK OUT ALL ELECTRICAL SERVICE BEFORE ENTERING FAN AREA.

Routine Starting Procedure

After periods of routine shutdown, the following restarting procedure should be followed:

1 Start the circulating water pump(s). Increase the flow of circulating water gradually to design water rate to avoid surges or water hammer which could damage the distribution piping.

△ **Caution**

Circulating cold water over a tower in freezing weather will cause ice to form—which may cause damage to the fill system. Water should be bypassed until the heat load causes its temperature to rise above 21°C (70°F), at which time it may be directed over the tower. Also, towers must not be operated with reduced water rate and/or no heat load during freezing weather. If a bypass is used, DO NOT MODULATE.

2 Start the fan(s). On multicell towers, only as many fans should be started as are needed to produce the desired cold water temperature. If the tower is equipped with two-speed motors, fans may be progressively started at half speed, increasing to full speed as necessary to maintain the desired cold water temperature. See **Temperature Control and Energy Management** on page 13.

Operation

TOWER PERFORMANCE—The following is intended to serve as a guideline for the operation of this crossflow mechanical draft cooling tower. The owner may use this information to develop preliminary operating procedures. As operational experience with the system accumulates, more definitive responses to specific conditions will be developed by the owner's operating personnel.

Keep the tower clean and the water distribution uniform to obtain continued maximum cooling capacity. See **Warning** on page 15. Do not allow excessive deposits of scale or algae to build up on the fill or eliminators. Keep the metering orifices free of debris to assure correct distribution and cooling of water.

The capacity of a tower to cool water to a given cold water temperature varies with the wet-bulb temperature and the heat load on the tower. As the wet-bulb temperature drops, the cold water temperature also drops. However, the cold water temperature does not drop as much as the wet-bulb temperature. **Wet-bulb temperature is the temperature indicated by the wet-bulb thermometer of a sling or mechanically aspirated psychrometer.**

A tower does not control the heat load. For a given heat load, the quantity of water circulated determines the cooling range. The hot and cold water temperatures increase with higher heat loads. **Cooling range is the temperature difference between the hot water coming into the cooling tower and the cold water leaving the tower.**

FAN DRIVE—Air is caused to move through the tower by the operation of electric motor-driven fans. At full speed, these fans are designed (and pitched) to move the amount of air required to accomplish the design thermal performance. Proper utilization of these fans provides the operator a means by which to adjust the level of thermal performance to suit the requirements of the load. See **Temperature Control and Energy Management** on page 13.

△ Caution

If two-speed motors are used, allow a time delay of a minimum of 20 seconds after de-energizing the high speed winding and before energizing the low speed winding. Tremendous stresses are placed on driven machinery and motor unless the motor is allowed to slow to low speed RPM or less before the low speed winding is energized.

When changing fan direction of rotation, allow a minimum of two minutes time delay before energizing the fan motor.

HOT WATER DISTRIBUTION SYSTEM—Keep metering orifices clean and in place in distribution basins. Adjust water flow to give the same depth in the distribution basins of all cells. Design water depth varies typically from 102 to 178 mm (4" to 7"), depending upon design circulating water rate.

If a major change in the quantity of water to be circulated over the tower is to be made, replace the removable metering orifices with ones of a correct orifice size to provide adequate water breakup and maintain the proper water level.

△ **Caution**

If an Amertap condenser tube cleaning system is part of plant equipment, care should be taken during operation to backwash the strainer section only after the sponge rubber cleaning balls are removed from the system by trapping them in the collector. If the balls are allowed to enter the cooling tower supply piping, they can clog the plastic metering orifices. Clogged orifices will cause unequal water distribution over the fill which will affect thermal performance. Extensive clogging can lead to overflowing the distribution basins and possible ice damage to towers installed in freezing climates. The basins should be frequently checked for orifice clogging until such time as the operational sequence of the Amertap system assures that no balls enter the cooling tower piping.

FILL—Water leaving the metering orifices is scattered uniformly over the fill plan area. The water cascades through the fill to maximize water surface exposure to the air being moved by the fans.

DRIFT ELIMINATOR—Air leaving the fill passes through drift eliminators blanketing the entire fill height of the tower. The purpose of these drift eliminators is to minimize the amount of water that is caused to exit the tower by the velocity of the moving airstream, and to direct the flow of air toward the fan.

COLD WATER COLLECTING BASIN—The normal water depth in the concrete basin is approximately 1100 mm (43 inches) below the curb (top of bottom louver). Adjust the makeup water supply to maintain this water level. Low operating depths of the water require air baffles under the fill to prevent air bypass. Maintain sufficient water depth to prevent cavitation.

Cold Weather Operation

During periods of low ambient air temperatures, 2°C to 4°C (35°F to 40°F) or below, it is advisable to maintain the cold water temperature at or above 21°C (70°F) to retard the formation of ice and to assist in its control. The methods used in "**MINIMIZING TOWER ENERGY USE**", described on page 13 are those which the operator would use to maintain water temperature at or above 21°C (70°F).

In combinations of low ambient air temperatures and reduced loads, fan speed manipulation may not be sufficient to maintain an acceptable water temperature. Even with fans off, the natural movement of air through the tower may be enough to continue reducing the water temperature. When that happens, if the tower is equipped with a bypass it will become necessary to open the bypass valve and allow total circulation to flow directly into the cold water basin until such time as the basin water inventory rises to a temperature level sufficiently high to preclude frequent change-overs from normal flow to bypass flow. That temperature level might be 29°C to 32°C (85°F to 90°F), but should be determined by operator experimentation.

DEICING—The formation of ice on towers operating in freezing weather cannot be completely prevented, but can be acceptably controlled. Ice will form on the relatively dry parts of the tower that are in contact with the incoming air. Primarily, this includes the louvers and adjacent structural framing. Ice forming characteristics on any given tower will vary, depending on velocity and direction of wind, circulating water rate and heat load.

A regularly programmed inspection (one walk around the tower per shift) during cold weather operation is the best way to determine if excessive ice buildup is occurring. Excessive ice formation may be controlled by regulating air and water flow through the tower by one or more of the following procedures:

- 1 Shut the fan down. This reduces the cooling rate to a minimum and increases the quantity of warm water on the louvers to a maximum. Except for extreme cold conditions or extended freezing conditions, this procedure will normally control ice formation. For automatic operation, a timer switch can be provided to shut the fan down for a few minutes each hour.
- 2 If the tower has two-speed motors, operate the fan at half speed forward. This reduces the cooling rate (heat transfer) and increases the quantity of warm water on the louvers.



3 Under extended extreme cold conditions, it may be necessary to operate the fan in reverse. This forces warm air out through the louvers, melting any accumulated ice. Reversal may be at either full or half speed, however, full speed is recommended if adequate heat load is available. Reverse operation of the fan should only be used to control ice, not prevent it. *Reverse fan operation should not exceed 15 to 20 minutes.* Usually much less time than this is required to melt accumulated ice.

△ **Caution**

Reverse operation of fans for prolonged periods during subfreezing weather can cause severe damage to fans and fan cylinders. Ice can accumulate inside fan cylinders at fan blade plane of rotation and fan blade tips will eventually strike this ring of ice, damaging the fan blades or cylinder. Ice can also accumulate on fan blades and be thrown off, damaging fan cylinder or blades. Reverse operation of fans with adjacent fans not operating increases probability of icing. The low discharge velocity of moist air from fan cylinders in which fans are not in operation can result in moisture-laden air being pulled into the adjacent cylinder in which the fan is operating in reverse, increasing this ice buildups. Therefore, fans each side of the one operating in reverse must be operated in forward rotation at full or half speed, or all fans must be operated in reverse. Allow a minimum of 10 minute delay between reverse operation and forward operation during subfreezing weather to permit ice to dissipate from fan blades and fan cylinders.

4 With no heat load on the circulating water, icing cannot be controlled effectively by air control alone during freezing weather. Towers must not be operated with reduced water rate and/or no heat load during freezing weather. If a bypass directly into the cold water basin is used, all water must be bypassed. ***Water flow over the tower must never be modulated during freezing weather.*** Design of a bypass arrangement must include consideration of water impact effect on tower components.

See FAN DRIVE page 9 for fan speed change and reversing precautions.

△ **Caution**

INTERMITTENT OPERATION—When the unit is operated intermittently during winter weather, it is necessary that the water be drained from the tower piping to insure protection against freezing and possible pipe and valve damage.

Temperature Control and Energy Management

The wet-bulb temperature of the ambient air varies significantly on a daily basis, and considerably from season to season. As the wet-bulb temperature reduces, the tower becomes capable of producing colder and colder water—or it becomes capable of producing a given cold water temperature at reduced airflow through the tower. These characteristics are the opposing forces referred to under **General** on page 4.

MAXIMIZING TOWER PERFORMANCE—If your operating system is one which benefits from the coldest possible water; that is, if colder water allows you to increase your output—or allows you to operate your system at significantly lower cost, then continuous full speed operation of the fan(s) may be your best mode of operation.

In this mode of operation, concern for the cold water temperature level would be limited to the potential for the tower to form ice during freezing weather. See **Caution** on page 8 and **Cold Weather Operation** on page 11. Although the 21°C (70°F) cold water temperature indicated on page 11 is appropriate for cold weather start-up and operation, acceptable temperatures during full operation in spring, summer and fall may be appreciably lower, perhaps as low as 10°C (50°F) or less. **Refer to your performance curves for expected tower cold water temperatures at varying flow rates, ranges, and wet bulb temperatures.**

MINIMIZING TOWER ENERGY USE—Many processes gain no operating or production benefits from water temperatures below a certain level, and for many that level may be only 5°C to 8°C (10°F to 15°F) below the design cold water temperature. When a reducing ambient wet-bulb permits the tower to reach that target cold water temperature level, further reductions in the wet-bulb temperature permit manipulation of fan speeds or operation to maintain that temperature level.

Single-speed fans can be cycled on and off for cold water temperature control, with the steps of control depending upon the number of fan cells in the tower. Two-speed motors offer twice as many control steps—with the added bonus that half-speed (which produces half of the normal airflow through the tower) requires less than 20% of the full-speed power requirement.

△ Caution

Excessive cycling of motors causes overheating of the windings and ultimate failure of the motor. The total amount of starting time (period of high inrush current) should not exceed 30 seconds per hour. On



fans 6096 mm (20'-0) diameter and smaller, this may allow 4 or 5 starts per hour. On larger fans, 1 or 2 starts per hour may be the limit. Determine the number of seconds it takes your fan to get to full-speed (by observation) and divide that number into 30 to obtain the recommended maximum number of starts per hour. Two-speed motors cycling between half and full speeds permit a commensurately greater number of control cycles.

Variable frequency drives, of course, provide the ultimate in both temperature control and energy management and can be easily retrofitted to your system. Please discuss this with your Marley representative.

Maintenance

Well maintained equipment gives the best operating results and the least maintenance cost. Marley recommends setting up a regular inspection schedule to insure effective safe operation of the cooling tower. Use the schedule on page 23 to obtain continuously good performance with least tower maintenance. See **Inspection Checklist** on page 26. Keep a continuous lubrication and maintenance record for each cooling tower. Conduct regular inspection and repair of personnel safety items (Table on page 23), and maintaining a record of this is especially important. For a supply of check list forms, contact your Marley sales office or representative.

△ Caution

HOT WATER DISTRIBUTION BASINS—Metering orifices in the floor of the hot water basins may be cleaned without shutting down any part of the tower. Remove dirt, algae, leaves, etc., which might get in these basins or orifices. ***Do not rod out nozzles. The plastic spray head could be permanently damaged.*** The metering orifices must be kept in place to assure proper water distribution.

Completely open and close flow control valves at least semi annually to remove any scale on the threads. Before operating valve, measure distance from valve stem guide to operating handle to assist in resetting the valve to the original operating position. Grease the stainless steel stem to prevent scale forming. Lubricate the valves at least semiannually with a lithium base NLGI No. 2 consistency grease. More frequent lubrication of valves and valve stems may be dictated by circulating water conditions.

FILL—Clean fill is key to the continued efficient operation and performance of a cooling tower. The owner/operator must keep the circulating water clean by treatment, screening, or filtering to avoid the presence of trash and debris, algae, slime and scale—with the effects of scale often being worsened by the presence of suspended muds. All of these can be controlled with some combination of water treatment, screening, and filtration, and it is the owner's responsibility to institute a program of water treatment and maintenance that will minimize their impact. See **Water Treatment** on page 18.

TOWER FRAMEWORK—Inspect for cracks and spalling and repair if necessary. Keep bolts tight in the mechanical equipment supports. Maintain a positive Langelier saturation index in your circulating water. See **Water Treatment** on page 18.



DRIVE SHAFT—Check drive shaft alignment and condition of couplings every six months. See the **Drive Shaft Service Manual** for correcting misalignment, balancing or replacing parts.

ELECTRIC MOTOR—Lubricate and maintain each electric motor in accordance with the manufacturer's instructions. If repair work is necessary, contact the nearest representative of the motor manufacturer. See Warranty Section of Marley **Service Manual on Electric Motors**.

FAN—Inspect fan blade surfaces every six months. For detailed maintenance information, refer to Marley **Fan User Manual**.

GEAREDUCER—Make weekly and monthly oil checks. Inspect internal parts during seasonal oil change. Refer to the **Geareducer Service Manual** for detailed maintenance instructions.

COLD WATER COLLECTING BASIN—Inspect collecting basin occasionally for cracks, leaks, and spalling and repair if necessary. Maintain a positive Langelier index in your circulating water. See **Water Treatment** on page 18. Keep cold water outlets clean and free of debris. Makeup and circulating water controls must operate freely and maintain the desired water quantity in the system.

Cooling Tower Cleaning

△ Warning

Any evaporative-type cooling tower must be thoroughly cleaned on a regular basis to minimize the growth of bacteria, including Legionella Pneumophilla, to avoid the risk of sickness or death. Service personnel must wear proper personal protective equipment. Do NOT attempt any service unless the fan motor is locked out.

Operators of evaporative cooling equipment, such as water cooling towers, should follow maintenance programs which will reduce to an absolute minimum the opportunity for bacteriological contamination. Public Health Service officials have recommended that “good housekeeping” procedures be followed, such as: regular inspections for concentrations of dirt, scale, and algae—periodic flushing and cleaning—and the following of a complete water treatment program including biocidal treatment.

Visual inspection should take place at least once a week during the operating season. Periodic flushing and cleaning should be done at least twice a year. Nozzles, louvers, drift eliminators, and easily accessible fill surfaces should be flushed by use of a moderate-pressure water nozzle, being careful not to cause physical damage. A reliable water treatment program should be installed and maintained.

Water Treatment

BLOWDOWN—Blowdown, or bleed-off is the continuous removal of a portion of the water from the circulating system. It is used to prevent dissolved solids from concentrating to the point where they will form scale. The amount of blowdown required depends upon the cooling range (design hot water temperature minus design cold water temperature) and the composition of the makeup water (water added to the system to compensate for losses by blowdown, evaporation and drift). The following table shows the amount of blowdown (percent of flow) required to maintain different concentrations with various cooling ranges:

COOLING RANGE	Number of Concentrations						
	1.5X	2.0X	2.5X	3.0X	4.0X	5.0X	6.0X
3°C (5.4°F)	0.844	0.412	0.268	0.196	0.124	0.088	0.066
6°C (10.8°F)	1.708	0.844	0.556	0.412	0.268	0.196	0.153
9°C (16.2°F)	2.572	1.276	0.844	0.628	0.412	0.304	0.239
12°C (21.6°F)	3.436	1.708	1.132	0.844	0.556	0.412	0.326
15°C (27°F)	4.300	2.140	1.420	1.060	0.700	0.520	0.412

Multipliers are based on drift of 0.02% of the circulating water rate.

EXAMPLE: 2000 L/s (31695.7 GPM) circulating rate, 10°C (18°F) cooling range. To maintain 4 concentrations, the required blowdown is 0.46% or .0046 times 2000 L/s (31695.7 GPM) which is 9.200 L/s (145.8 GPM).

If tower is operated at 4 concentrations, circulating water will contain four times as much dissolved solid as the makeup water, assuming none of the solids form scale or are otherwise removed from the system.

△ Note

The use of corrosion and scale inhibitors is strongly recommended.

CHEMICAL TREATMENT—In some cases chemical treatment of the circulating water is not required if adequate blowdown is maintained. In most cases, however, chemical treatment is required to prevent scale formation and corrosion. Sulfuric acid or one of the polyphosphates is most generally used to control calcium carbonate scale. Various proprietary materials containing phosphates or other compounds are available for corrosion control. When water treatment chemicals are required, the services of reliable water treating companies should be obtained.

△ Note

The circulating water pH should be maintained between 7.0 and 8.5.

The Langelier index (calcium carbonate saturation index) has proven to be an effective tool in predicting the aggressiveness of cooling tower water toward concrete. The Langelier index relates the methyl orange alkalinity; the calcium hardness; the total solids; the pH value; and the temperature of the water. From these values it is possible to calculate the index and

predict the corrosive tendencies of the tower water toward concrete. An explanation and method of calculating the Langelier index can be found in books on water treatment. Maintaining a positive Langelier index provides excellent protection of concrete.

Slime, a gelatinous organic growth, and algae, a green or brown plant growth, may grow in the cooling tower or heat exchangers. Their presence can interfere with cooling efficiencies. Proprietary compounds are available from water treating companies for the control of slime and/or algae; however, compounds which contain copper are not recommended.

△ **Caution**

Chlorine, if used, should be introduced at a point in the circulating water system that will promote rapid dispersal, and residual chlorine should not exceed that which is required to reasonably control slime and algae.

SCALING—Scale can be caused by the uncontrolled presence of sulfates, silicates, carbonates, or oxides, and their effect can be accentuated by the presence of suspended muds. Some suggestions and limitations follow:

- **Calcium sulfate** may be introduced in the makeup water stream and/or produced by the use of sulfuric acid for pH adjustment. The concentration of calcium sulfate should be kept below 1000 ppm, expressed as CaCO_3 .
- **Calcium carbonate** generally will not form scale in the cooling tower if carbonate scaling does not occur in the condenser. However, if makeup water contains surplus free carbon dioxide, scaling may be inhibited in the condenser but may occur in the fill because of CO_2 stripping.
- **Silica** scale is virtually impossible to remove. However, silica scale is unlikely if concentrations of SiO_2 are held below 150 ppm.
- **Oxides**, such as iron oxide, can coat all parts of the system if soluble iron is present in concentrations above 0.5 ppm. Iron oxides do not usually develop into thick scales but, like mud, can accentuate the development of other scales.

FOAMING—Heavy foaming sometimes occurs when a new tower is put into operation. This type of foaming generally subsides after a relatively short period of operation. Persistent foaming can be caused by the concentrations of certain combinations of dissolved solids or by contamination of the circulating water with foam-causing compounds. This type of foaming can sometimes be minimized by increasing the blowdown, but in some cases foam depressant chemicals must be added to the system. Foam depressants are available from a number of chemical companies.

Seasonal Shutdown

TOWER—Drain all tower piping.

During shutdown, clean the tower and make any necessary repairs. Apply protective coating as required to all metal parts. Particular attention should be given to mechanical equipment supports, drive shaft and drive shaft guards.

△ Note

See Warning on page 17 regarding tower cleaning.

Visually inspect for concrete deterioration. *If ambient temperature is 0°C (32°F) or below, do not put cold water on tower.*

MECHANICAL EQUIPMENT

Shutdown for less than 3 months.

Each month, drain water condensate from the lowest point of the Geareducer and its oil system. Check oil level and add oil if necessary. Operate Geareducer to recoat all interior surfaces with oil. At start-up, drain water condensate and check oil level. Add oil if necessary.

Refer to **Geareducer Service Manual** for maintenance and lubrication instructions.

Shutdown for 3 months or longer.

If the motors have space heaters, operate mechanical equipment one hour each month. Space heaters should be energized anytime motor is not operating. If the motors do not have space heaters, operate mechanical equipment one hour each week. At start-up, operate mechanical equipment one hour or until oil is warm, then shut the equipment down. Drain the oil and refill with new oil.

Refer to **Geareducer Service Manual** for instruction on changing oil. Refer to Marley **Downtime Instruction Manual** for downtime of 6 months or longer.

ELECTRIC MOTORS

△ Caution

Do not start motor without determining that there will be no interference with free rotation of the fan drive. Refer to Marley **Electric Motor Service Manual**.

If shutdown period is longer than seasonal, contact your Marley sales office or representative for additional information.

Spare Parts and Accessories

Marley manufactures and maintains a stock of replacement parts for all cooling tower mechanical equipment. Shipment of these parts are normally made within ten days after an order is received. If emergency service is necessary, contact the local Marley sales office or representative for assistance.

To prevent prolonged shutdown periods in case of damage to the mechanical equipment, it is recommended that the following parts be carried in the owner's stock:

- One fan assembly.
- One Geareducer assembly.
- One drive shaft assembly.
- One electric motor.

Be sure to furnish the tower serial number when ordering parts.

Marley has designed (or will design, at your request) many accessories devoted to improved maintenance access, safety, component handling, and the general customization of the tower to suit your process. These accessories include stairways, walkways (external and internal), mechanical equipment removal systems, derricks, davits, hot water basin covers (for algae suppression), as well as variable frequency drives (page 13) and other retrofittable control devices.

Please discuss your needs with your Marley representative.

Troubleshooting

Trouble	Cause	Remedy
Motor Will Not Start	Power not available at motor terminals	<ol style="list-style-type: none"> 1. Check power at starter. Correct any bad connections between the control apparatus and the motor. 2. Check starter contacts and control circuit. Reset overloads, close contacts, reset tripped switches or replace failed control switches. 3. If power is not on all leads at starter make sure overload and short circuit devices are in proper condition.
	Wrong connections	Check motor and control connections against wiring diagrams.
	Low voltage	Check nameplate voltage against power supply. Check voltage at motor terminals.
	Open circuit in motor winding	Check stator windings for open circuits.
	Motor or fan drive stuck	Disconnect motor from load and check motor and Geareducer for cause of problem.
	Rotor defective	Look for broken bars or rings.
Unusual Motor Noise	Motor running single-phase	Stop motor and attempt to start it. Motor will not start if single-phased. Check wiring, controls and motor.
	Motor leads connected incorrectly	Check motor connections against wiring diagram on motor.
	Ball bearings	Check lubrication. Replace bad bearings.
	Electrical unbalance	Check voltages and currents of all three lines. Correct if required.
	Air gap not uniform	Check and correct bracket fits or bearing.
	Rotor unbalance	Rebalance.
Motor Runs Hot	Cooling fan hitting guard	Reinstall or replace fan.
	Wrong voltage or unbalanced voltage	Check voltage and current of all three lines against nameplate values.
	Overload	Check fan blade pitch. See Fan Service Manual . Check for drag in fan drive train as from damaged bearings.
	Wrong motor RPM	Check nameplate against power supply. Check RPM of motor and gear ratio.
	Bearings over greased	Remove grease reliefs. Run motor up to speed to purge excessive grease.
	Rotor rubs stator bore	If not poor machining, replace worn bearing.
	Wrong lubricant in bearings	Change to proper lubricant. See motor manufacturer's instruction.
	One phase open	Stop motor and attempt to start it. Motor will not start if single-phased. Check wiring, controls and motor.
	Poor ventilation	Clean motor and check ventilation openings. Allow ample ventilation around motor.
	Winding fault	Check with Ohmmeter
	Bent motor shaft	Straighten or replace shaft.
	Insufficient grease	Remove plugs and grease bearings.
	Deterioration of or foreign material in grease	Flush bearings and lubricate.
	Bearings damaged	Replace bearings.
	Incorrect fan blade pitch	See Fan Service Manual for blade pitching instructions.
Motor Does Not Come Up To Speed	Voltage too low at motor terminals because of line drop	Check transformer and setting of taps. Use higher voltage on transformer terminals or reduce loads. Increase wire size or reduce inertia.
	Broken rotor bars	Look for cracks near the rings. A new rotor may be required. Have motor service man check motor.

Troubleshooting

Trouble	Cause	Remedy
Wrong Rotation (Motor)	Wrong sequence of phases	Switch any two of the three motor leads.
Geareducer Noise	Geareducer bearings	If new, see if noise disappears after one week of operation. Drain, flush and refill Geareducer. See Geareducer Service Manual . If still noisy, replace.
	Gears	Correct tooth engagement. Replace badly worn gears. Replace gears with imperfect tooth spacing or form.
Unusual Fan Drive Vibration	Loose bolts and cap screws	Tighten all bolts and cap screws on all mechanical equipment and supports.
	Unbalanced drive shaft or worn couplings	Make sure motor and Geareducer shafts are in proper alignment and "match marks" properly matched. Repair or replace worn couplings. Rebalance drive shaft by adding or removing weights from balancing cap screws. See Drive Shaft Service Manual .
	Fan	Make certain all blades are as far from center of fan as safety devices permit. All blades must be pitched the same. See Fan Service Manual . Clean off deposit buildup on blades.
	Worn Geareducer bearings	Check fan and pinion shaft end-play. Replace bearings as necessary.
	Unbalanced motor	Disconnect load and operate motor. If motor still vibrates, rebalance rotor.
	Bent Geareducer shaft	Check fan and pinion shaft with dial indicator. Replace if necessary.
Fan Noise	Loose fan hub cover	Tighten hub cover fasteners.
	Blade rubbing inside of fan cylinder	Adjust cylinder to provide blade tip clearance.
	Loose bolts in blade clamps	Check and tighten if necessary.

Safety

The tower has been designed to provide a safe working environment while either operating or shut down. The ultimate responsibility for safety rests with the Operator and Owner. When flow to the tower is shut off or when portions of the tower require maintenance, temporary safety barricades may be required around openings. Other safety precautions such as safety harnesses should be utilized where appropriate for compliance with OSHA regulations and standards and good safety practices. See **Warning** on page 17.

Routine periodic maintenance must be performed on all personnel access and material handling accessories in accordance with the following schedule:

	Ladders, Stairways, Walkways, Guardrails, Covers, Decks and Access Doors	Davits, Derricks, Hoist
Inspect for General Condition	Semi-annually	Semi-annually
Inspect and Repair for Safe Use	Yearly	
Inspect and Repair Before Each Use		As Required

Inspection and Maintenance Schedule

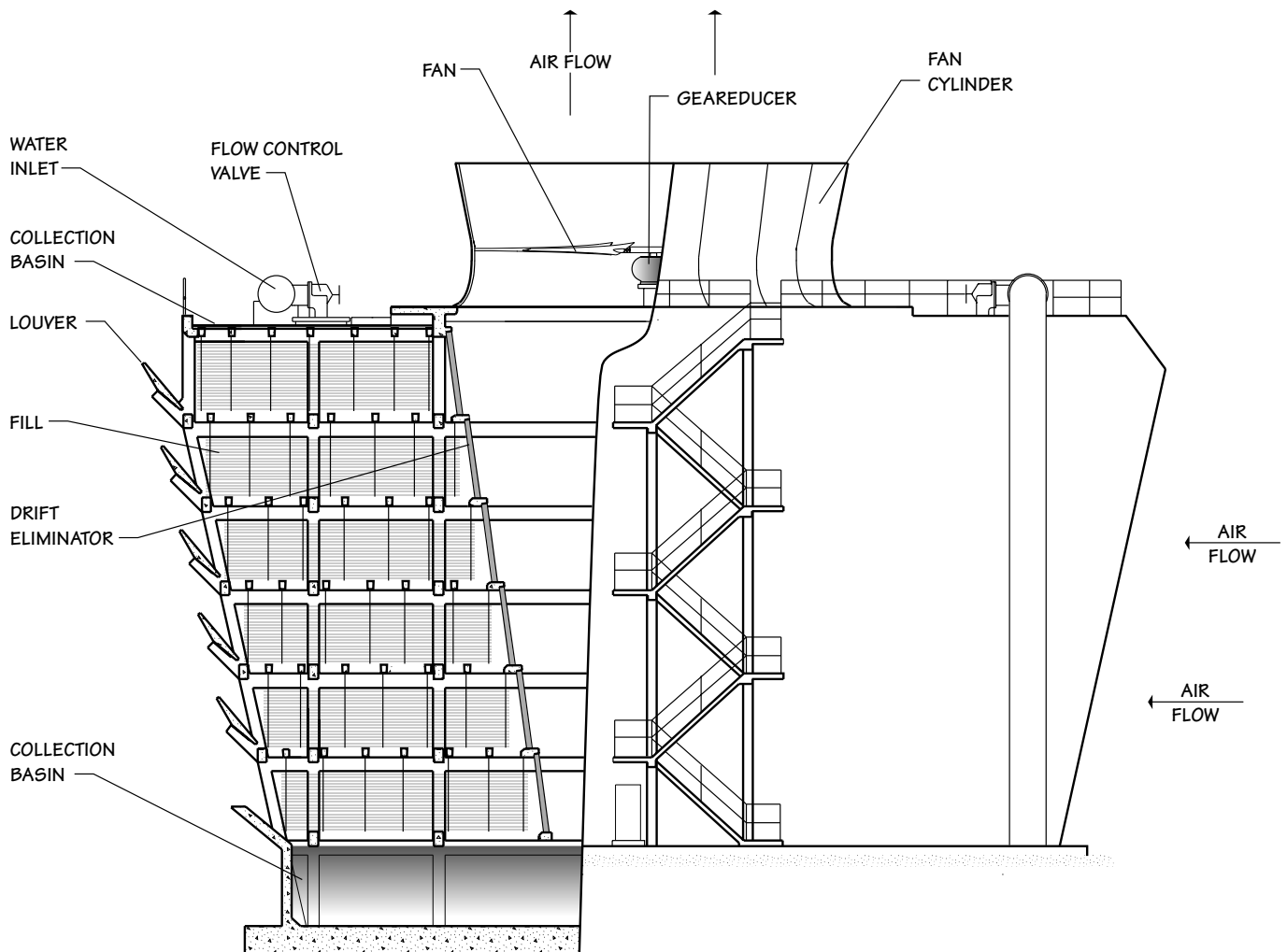
General Recommendations

More frequent inspection and maintenance may be desirable

	Fan	Motor	Driveshaft and Guards	Gearreducer	Drift Eliminators	Fill and Grids	Cold Water Basin	Hot Water Basin	Float Valve	Suction Screen	Control Valves	Structural Members	Casing and Louvers	Fan Cylinder	Stairs, Ladders, Walkway, Doors, Guardrails	Davits, Derricks, Hoists
1. Inspect for clogging					M	M		W		W						
2. Check for unusual noise or vibration	D	D	D	D												
3. Inspect keys, keyways and set screws	S	S	S	S												
4. Make sure vents are open				S												
5. Lubricate (grease)		R									S					
6. Check oil seals				M												
7. Check operating oil level				D												
8. Check static oil level				M												
9. Check oil for water and sludge				M												
10. Change oil				S												
11. Check fan blade tip clearance	S															
12. Check water level							D	D								
13. Check for leakage				W			S	S	S							
14. Inspect general condition	S	S	S	S	Y	S	Y	S	Y	S	S	S	Y	S	S	S
15. Tighten loose bolts	S	S	S	S								Y	R	S		
16. Clean	R	R	R	R	R	R	S	R	R	R	R					
17. Repaint	R	R	R	R												
18. Rebalance	R		R													
19. Completely open and close											S					
19. Inspect/repair for safe use	Y		Y												Y	
20. Inspect and repair before each use																R

D – daily; W – weekly; M – monthly; Q – quarterly; S – semi-annually; Y – yearly; R – as required

Class 1000 Tower Cross Section



Inspection Checklist

Date Inspected _____ Inspected By _____
 Owner _____ Location _____
 Owner's Tower Designation _____
 Tower Manufacturer _____ Model No. _____ Serial No. _____
 Process Served by Tower _____ Operation: Continuous ☐ Intermittent ☐ Seasonal ☐
 Design Conditions GPM _____ HW _____ °F CW _____ °F WB _____ °F
 Number of Fan Cells _____

Condition: 1—Good 2—Keep an eye on it 3—Needs immediate attention

Structure

Casing Material _____
 Structural Material _____
 Fan Deck Material _____
 Stairway? _____ Material _____
 Ladder? _____ Material _____
 Guardrails? _____ Material _____
 Interior Walkway? _____ Material _____
 Cold Water Basin Material _____

1	2	3	Comments

Water Distribution System

Distribution Basin Material _____
 Inlet Pipe Material _____
 Inlet Manifold Material _____
 Flow Control Valves? _____ Size _____ In.
 Nozzles — Orifice Diameter _____ inches

Heat Transfer System

Fill _____
 Drift Eliminators _____
 Louvers _____

Use this space to list specific items needing attention: _____

Inspection Checklist

Condition: 1—Good 2—Keep an eye on it 3—Needs immediate attention

Mechanical Equipment

1	2	3	Comments
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Gear Drive Units

Manufacturer	Model	Ratio
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Oil Level: Full ☐ Add Immediately ☐ Low, check again soon ☐

Oil Condition: ☒ Good ☐ Contains Water ☐ Contains Metal ☐ Contains Sludge ☐

Oil Used — Type

Seals

Back Lash

Fan Shaft End Play

Any Unusual Noises? No ☐ Yes ☐

Action Required:

Drive Shafts

Manufacturer	Material
--------------	----------

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Fans

Manufacturer

Fixed Pitch ☐ Adjustable Pitch ☐

Diameter

Number of Blades

Blade Material

Hub Material

Hub Cover Material

Blade Assembly Hardware

Tip Clearance	"min.	"max.
---------------	-------	-------

Vibration Level

Fan Cylinder Height

Mech.Eqpt. Support Mat'l

Oil Fill & Drain Lines

Oil Level Sight Glass

Vibration Limit Switches

Make-up Valves

Other Components

[illegible]

Motor Manufacturer

Name Plate Data: HP RPM Phase Hz Volts

F.L. Amps	Frame	S.F.	Special Info.
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Last Lubrication — Date

Grease Used — Type

Any Unusual Noise?	No <input type="checkbox"/>	Yes <input type="checkbox"/>	Action Required

Any Unusual Vibration?	No <input type="checkbox"/>	Yes <input type="checkbox"/>	Action Required

Anu Unusual Heat Build-up?	No <input type="checkbox"/>	Yes <input type="checkbox"/>	Action Required

Health Alert

Among other sources, outbreaks of Legionnaires' Disease have reportedly been traced to cooling towers. Maintenance procedures that prevent amplification and dissemination of Legionella and other airborne bacteria should be formulated and implemented BEFORE systems are operated and continued regularly thereafter to avoid the risk of sickness or death. The following is recommended:

- ☐ Do NOT attempt any service unless the fan motor is locked out.
 - ☐ New cooling towers should be cleaned and treated with biocides by a water treatment expert before startup. See your Cooling Tower User Manual for more detailed instructions on biocidal treatment.
 - ☐ At a minimum, cooling towers should be cleaned and disinfected with biocides twice a year. Systems with biofouling or positive cultures of legionella may require additional cleaning.
 - ☐ Units should be inspected weekly for bacterial growth and general operating conditions. Bacterial growth should be reported to your water treatment expert for immediate attention.
 - ☐ Drift eliminators should be inspected monthly. Any debris or scale should be cleaned off the eliminators when noted. Replace any damaged or worn out components.
 - ☐ Workers cleaning units should use protective clothing and equipment during decontamination.
 - ☐ Although using these practices will not guarantee that a system or individual component will not be contaminated by legionella, they should reduce the chance of colonization.
- For additional copies of the tower User Manual or other literature pertaining to this unit, please contact your Marley sales representative.

SPX **Cooling Technologies**

Balcke | Hamon Dry Cooling | Marley